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MODELLING OF AN INFILL WALL FOR THE ANALYSIS OF A BUILDING FRAME SUBJECTED TO LATERAL FORCE

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ABSTRACT

In general the analysis of a building frame is carried out with a bare frame but the presence of masonry infill in a framed structure results in high stiffness and influence the distribution of lateral load and also the response of the framed buildings. It can be noted that there is a large variation of mechanical properties of bricks. Masonry, a combination of brick and mortar, behaves in a highly nonlinear manner. The infill panel needs to be modelled in the analysis of a structural frame subjected to lateral load to obtain its true behaviour. In order to model the masonry infill, its properties required. In order to determine the properties of brick masonry compression tests were conducted on masonry infill panels and prisms.

In the present experimental investigation the masonry panel and prism specimens were prepared using the combinations of three different proportions of Cement Mortar 1:2, 1:4 and 1:8 and bricks procured from three different sources. These masonry panels and prisms were tested in compression along the vertical and diagonal directions respectively.

Using the test results and curve fitting software the compressive strength of masonry panels and prisms are expressed as a function of strength of cement mortar and the strength of brick.

To illustrate the influence of infill wall on the behaviour of a building frame the infill wall is modelled for the analysis. Researchers modelled the infilled wall in different ways. In the present study the infilled wall is modelled as a Single Struts with width equal to One fourth of Length of the diagonal and thickness equal to thickness of the infill wall.

It can be observed that the presence of infill wall not only results in stiffer frame and as the infill wall is also contributing the lateral load resistance the magnitude of bending and shear force in the beam and column members of the frame will be reduced. It can be recommended that the infill needs to be modelled in the frame analysis to predict its behaviour close to its exact behaviour.

Key words: Masonry Infill, Masonry Prism, Compression Strength, Diagonal Strut, Curve fitting and Stiffness.

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1. INTRODUCTION

The analysis of multistory buildings frames subjected to vertical loads is well established, but the lateral loads due to wind or earthquake are of great concern and need special consideration. These lateral forces can produce the critical stress in a structure, vibrations, and in addition, cause lateral sway of the structure which can reach a stage of discomfort to the occupants. Although the infill panels significantly enhance the stiffness of the frame, their contribution is often not taken into account in the analysis of a frame because of the lack of knowledge of the behaviour masonry infill.

The experiences from past seismic events indicate that the infill influence structural elements. An important example is the collapse of columns under shear loading effects as a consequence of frame infill interaction. Furthermore, the effect of infill on structural behaviour is also very important as they can make the structure stiffer and attract more seismic loads.

The present study begins with detailed experimental investigation with three types of mortar and bricks obtained from the three different sources used for the preparation of masonry panels and prisms and subject to compression tests along the vertical and diagonal directions. Using the compression test results and Curve fitting software, relations are derived for the compressive strength of masonry panel and masonry prism as a function of compressive strength of brick and cement mortar.

To obtain the actual behaviour of a building frame the infill wall is modelled for the analysis. Researchers modelled the infilled wall in different ways. In the present study the infilled wall is modelled as a single strut with width equal to one fourth of length of the diagonal and thickness equal to thickness of the infill wall.

It is observed that the presences of infilled wall not only results in stiffer frame but also the magnitude of bending and shear forces in the beam and column members of the frame will also be reduced. Hence, infill needs to be modelled in the frame analysis to obtain its behaviour close to its exact behaviour.

2. EXPERIMENTAL PROGRAMME

2.1. Materials

2.1.1. Cement

The cement used in present investigation is Ordinary Portland Cement (OPC) 43 grade confirming to IS specifications. The normal consistency of cement obtained as 33% and the compression strength of cement is 43N/mm^2.

2.1.2. Sand

The sand used in present investigation is obtained locally from river and confirming to IS specifications with fineness modulus of 2.78

2.1.3. Water

Potable water with PH value of 7.85 is used for the preparation and curing test specimens, which is free from acids, organic matter, suspended solids and impurities.

2.1.4. Bricks

The bricks used in present investigation are obtained locally from three different sources. Brick dimensions, compressive strength and water absorption results are presented in Table. No.1. The compressive strength and water absorption are calculated as an average of six bricks from each source.

Table 1 Brick Dimensions

S.No	Brick	Brick Dimensions L x B x D (mmx mm x mm)	Compressive Strength of Brick (N/mm2)	Water Absorption (%)
1	Type A	223×103×80	9.1	12.81
2	Type B	230×105×80	6.9	13.06
3	Type C	230×109×80	6.4	13.44

2.2. Preparation of Test Specimens

2.2.1. Preparation of Masonry Panel and Masonry Prism

Three different proportions of cement mortar (1:2, 1:4 and 1:8) and three different sources of bricks (Type A, Type B and Type C) are utilized in all 9 combination to prepare masonry panel test specimens of size 700 mm × 700 mm dimension. From the masonry panel, prism specimens of size 500 mm × 500 mm is cut out of it with a cutter.

2.3. Testing

2.3.1. Compression Test on Masonry Panel

The compressive strength of masonry panel specimens was obtained. Masonry panel is tested in compression and the load is applied using hydraulic jack till the masonry panel fails. The maximum load at failure is recorded to calculate compression strength of masonry panel.

2.3.2. Compression Test on Masonry Prism

The compressive strength of masonry prism specimens was obtained. Masonry prism is also tested in compression and the load is applied using hydraulic jack till the masonry prism fails. The maximum load at failure is recorded to calculate compression strength of masonry prism.

2.4. Summary of Tests Results

The results of the experimental work carried out on cement motor, bricks, masonry panels and masonry prism specimens are presented in Table No.2 and also shown in Fig.1.

Table.2 Summary of Test Results

Proportion of Cement Mortar	Strength of Mortar (N/mm^2)	Brick	Strength of Brick (N/mm^2)	Strength of Masonry Panels (N/mm^2)	Strength of Masonry Prisms (N/mm^2)
1:2	44.89	Type A	9.1	1.84	1.62
		Type B	6.9	1.41	1.31
		Type C	6.4	1.32	1.22
1:4	40.82	Type A	9.1	1.51	1.38
		Type B	6.9	1.26	1.20
		Type C	6.4	1.16	1.06
1:8	37.41	Type A	9.1	1.35	1.19
		Type B	6.9	1.11	1.00
		Type C	6.4	1.02	0.80

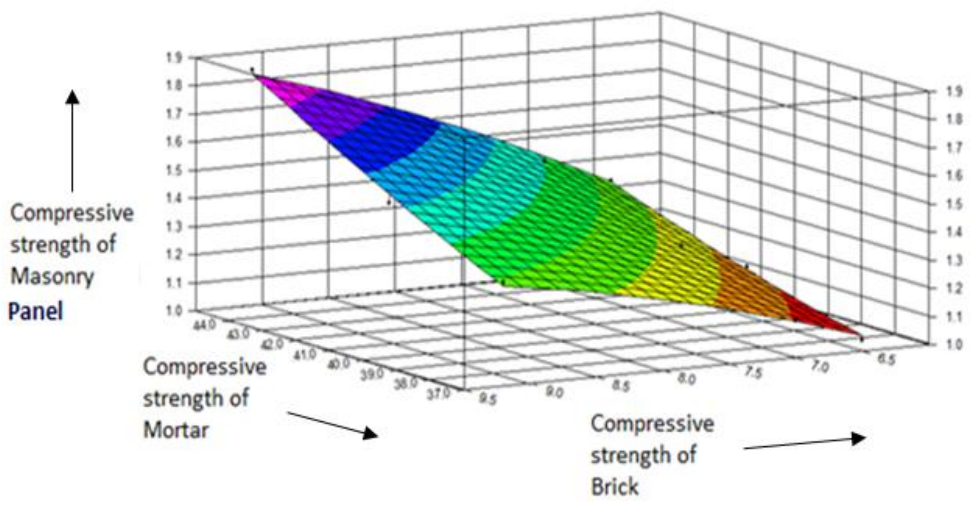

Figure 1(a) Variation of Compressive Strength of Masonry Panel

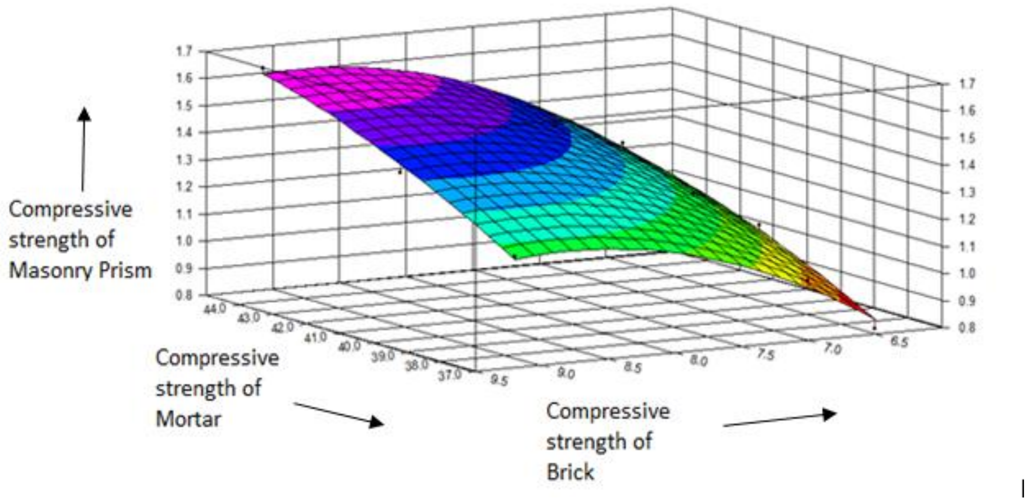

Figure 1(b) Variation of Compressive Strength of Masonry Prism

3. RESULTS AND DISCUSSION

Using the test results, equations are derived for compression strength of masonry panel and masonry prisms in terms of strength of brick and strength of cement mortar. Curve fitting software, was used to obtain the equation of the best-fit.

3.1. Strength of Masonry Panel

The proposed best-fit equation to obtain the strength of masonry panel (*SMP*) in terms of strength of mortar (*SM*) and strength of brick (*SB*) is given below:

$SMP = ab^{SM}SB^{c}$

Where,

SMP = Compressive strength of Masonry Panel (N/mm^2)

SM = Compressive strength of Mortar (N/mm^2) and

SB = Compressive strength of Brick (N/mm^2).

Constants of the proposed equation are a = *0.055, b = 1.038 and c = 0.83.*

The strength of the best-fit equation (R^2) is *0.9878*

The comparison between the strength of masonry panel obtained from the experimental work and the best-fit equation is shown in Table. 3.

Table 3 Compression between the Experimental and Best-fit curve results

Strength of Mortar *(SM)* (N/mm2)	Strength of Brick *(SB)* (N/mm2)	Strength of Masonry Panel *(SMP)* (N/mm^2)	
		Experimental Results	Obtained from the Proposed Equation Simplified Equation
44.89	9.1	1.84	1.83
44.89	6.9	1.41	1.46
44.89	6.4	1.32	1.37
40.82	9.1	1.51	1.56
40.82	6.9	1.26	1.25
40.82	6.4	1.16	1.18
37.41	9.1	1.35	1.39
37.41	6.9	1.11	1.10
37.41	6.4	1.02	1.04

3.2. Strength of Masonry Prism

The proposed best-fit equation to obtain the strength of masonry prism (*SMPR*) in terms of strength of mortar (*SM*) and strength of brick (*SB*) is given below:

SMPR = a+b/SM+c/SB

Where,

SMPR= Compressive strength of Masonry Prism (N/mm^2)

SM = Compressive strength of Mortar (N/mm^2) and

SB = Compressive strength of Brick (N/mm^2)

The Constants of the proposed equation are a = 4.37, b = -86.82 and c = -7.62.

The strength of the best-fit equation (R^2) is 0.9706

The comparison between the strength of masonry panel obtained from the experimental work and the best-fit equation is shown in Table. 4.

Table 4 Compression between the Experimental and Best-fit curve results

Strength of Mortar (N/mm2)	Strength of Brick (N/mm^2)	Strength of Masonry Prism (N/mm^2)	
		Experimental Results	Obtained from Proposed Equation
			Simplified Equation
44.89	9.1	1.62	1.60
44.89	6.9	1.31	1.33
44.89	6.4	1.22	1.25
40.82	9.1	1.38	1.41
40.82	6.9	1.20	1.14
40.82	6.4	1.06	1.05
37.41	9.1	1.19	1.21
37.41	6.9	1.00	0.94
37.41	6.4	0.80	0.86

4. ANALYTICAL MODELLING AND ANALYSIS OF A FRAME

In order to study the influence of an infill wall on the behaviour of a frame, analysis was carried out on single-storeyed single-bay bare frame and the frame in which the infill is modelled as a compression strut. For modeling of a masonry infill “Equivalent Diagonal Strut Method” is adopted. The following are the parameters taken into consideration for the modeling an infill wall.

- Width of the diagonal struts (W_s) is considered as one-fourth of the diagonal length of infill.
- Thickness of the diagonal strut is equal to thickness of the infill wall
- Strength of the compression strut is equal to the strength of the masonry prism.
- Modulus of elasticity of masonry (E_m) is taken as $550\ f_m$ in MPa. Where, f_m is the compressive strength of masonry prism in MPa.

The frame is chosen satisfying the Strong Column-Weak Beam. The frame consists of a beam of ISMB300 section and Column of ISMB350. The lateral deformation and the bending moment diagrams of the bare and infill frames are shown in Fig.

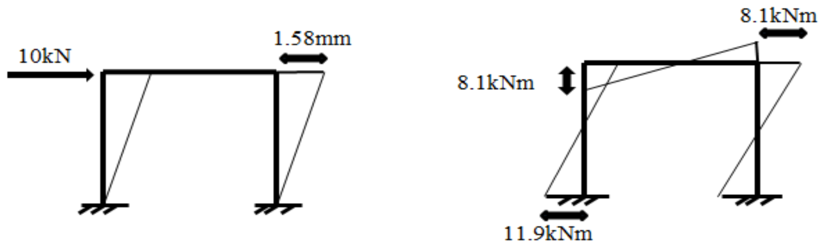

Figure 3(a) Bare Frame with Lateral load and the Bending Moment Diagram

Stiffness of the frame (k) = 10 kN /1.58 mm = 6.33 x 10^3 kN/m

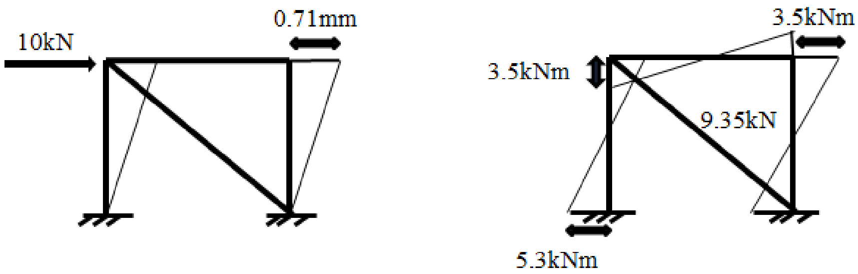

Figure 3 (b) Infill Frame with Lateral load and the Bending Moment Diagram

Stiffness of the frame (k) = 10 kN / 0.71mm = 14.1 x 10^3 kN/m.

It can be observed that the stiffness of an infill frame modelled using Equivalent Diagonal Strut is 2.2 times the bare frame. As the stiffness of the frame with infill increases, the frame has to be designed to resist lateral forces of increased magnitude.

5. CONCLUSIONS

Compression tests were carried out on masonry specimens prepared using three different mortars with proportions (1:2, 1:4 and 1:8) and three types of bricks from three different sources. The maximum load at failure is used to calculate Compressive Strength of Masonry panel and Prism. For deriving Compression Strength equations curve fitting software was used.

Equations are derived for compressive strength of masonry using Curve Fitting Software:

- Strength of Masonry Panel as a function of strength of brick and cement mortar and
- Strength of Masonry Prism as a function of strength of brick and cement mortar

To obtain the actual behaviour of a building frame the infill wall is modelled for the analysis. In the present study the infilled wall is modelled as a Single Struts with width equal to one-fourth of the length of the diagonal and thickness equal to thickness of the infill wall.

It is observed that the presences of infilled wall not only results in a stiffer frame but also the magnitude of bending and shear forces in the beam and column members of the frame will be reduced. Hence infill needs to be modelled in the frame analysis to obtain its behaviour close to its exact behaviour.

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